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# Development of CANMETCOAT Digger Teeth for Oil Sands Bucket Wheel Reclaimer Service

K.G. Davis and J.-G. Magny

MTL 89-70(TR)

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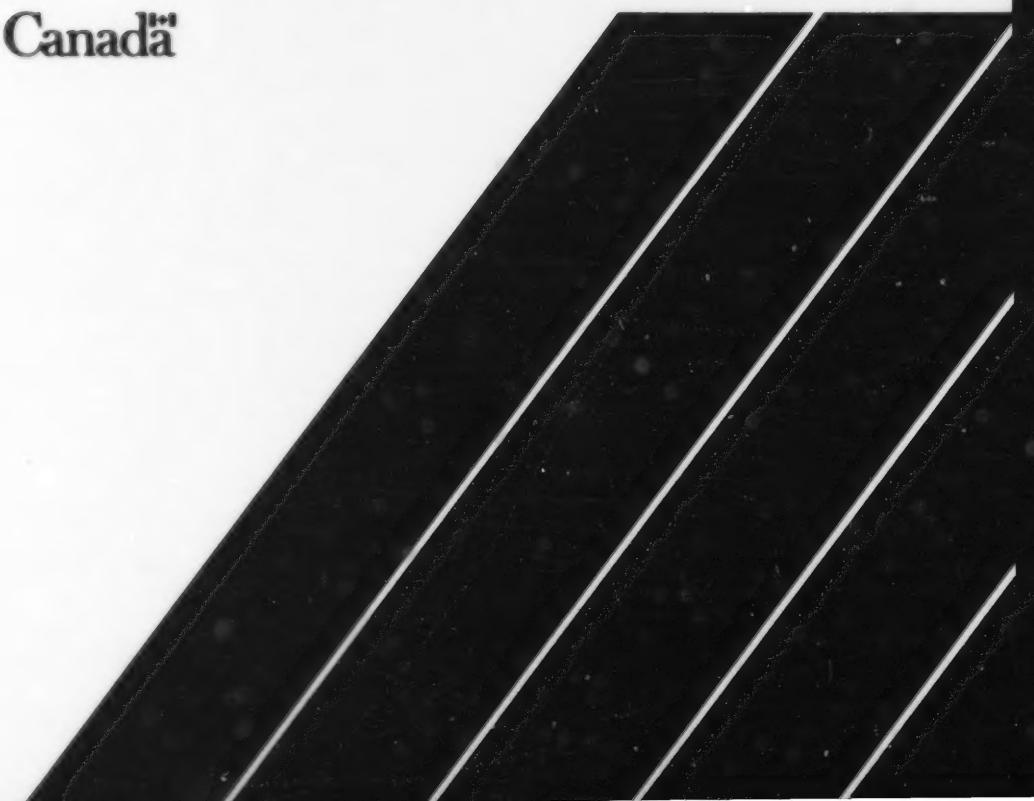

# METALS TECHNOLOGY LABORATORIES

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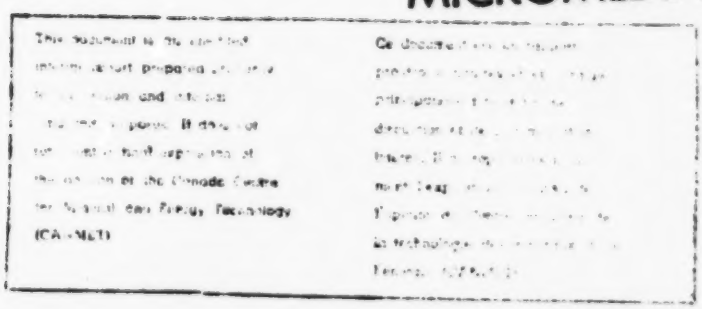

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REPORT MTL 89-70(TR)

# DEVELOPMENT OF CANMETCOAT DIGGER TEETH FOR OIL SANDS BUCKET WHEEL RECLAIMER SERVICE

by

K.G. Davis and J.-G. Magny

## ABSTRACT

This report describes the development of the CANMETCOAT process for the production of digger teeth with "in-situ" hardfaced surfaces. These teeth have been successfully field tested at the Syncrude oil sands plant.

## RÉSUMÉ

Ce rapport décrit le procédé "CANMETCOAT" de production d'une dent de creusage coulée avec des surfaces résistantes à l'abrasion. Ces dents furent testées dans des champs de sable bitumineux de Syncrude.

# PART 1. BACKGROUND

## DEVELOPMENT OF THE CANMETCOAT PROCESS

The normal procedure to obtain a layer of wear-resistant material on the surface of a casting is to first make the part, then clean the surface to be coated and use a welding process for depositing the wear-resistant material. It has long been realised by foundrymen that there is an alternative, potentially cheaper way to attain the same goal. The alternative is to hold wear-resistant material on the surface of the mould cavity in some manner so that when the casting is poured, the material on the mould cavity surface becomes part of the casting. The main problems with this approach are that, at one extreme, the poured metal does not react with the surfacing material, while at the other extreme the incoming metal dissolves the coating material and sweeps it away from the surface into the bulk of the casting. In either case, there is no useful hard facing. These extremes must be avoided by a suitable choice of coating material, and by gating design that minimizes turbulence at the coating area.

The concept of an as-cast coating is far from new. Figure 1 is taken from a patent for an impeller casting (1) in which trays made of cardboard, filled with a manganese alloy, are positioned so that a carbon steel casting with high-Mn areas can be cast. This was filed in 190[illegible]. It had not a shadow of a chance of succeeding in its purpose, but serves as an indication of the effort and ingenuity put into this area over the years. More recently (2), there have been numerous Russian papers and patents in which "pastes" containing a mixture of flux and coating material are painted or trowelled onto the mould cavity surface. Success has been claimed, but the usage does not appear to be widespread. With our current experience it is easy to see that slag and blowing in the vicinity of such a paste must present major problems.

The current project originated some ten years ago at a meeting between representatives of CANMET and the oil-sands industry to consider areas of interaction. One area identified as proving troublesome at that time was the wear rate on digger teeth. CANMET's Foundry Section already had some experience with locating green compacts of wear-resistant nickel-based powders on the surfaces of cast iron plates (3), and it was suggested that the same technique might work for digger teeth. With the encouragement of a commercial foundry, we set out to produce digger teeth with as-cast surface coatings. The original concept of locating green or pre-sintered compacts of wear resistant material on a mould cavity surface was not successful. First, blow holes were often produced at the casting/compact interface. Second, one of the two extreme conditions referred to earlier was often encountered, i.e. either the steel did not penetrate the compacts which fell off the casting on its removal from the mould, or the compact material completely dissolved in the steel with widespread mixing, and much of the coating material was swept away from the surface. It seemed hard to find a middle position where the compacts were infiltrated by, and bonded with, the poured alloy but remained essentially in place.

At this stage, the idea arose to use vacuum to suck the molten metal into the compact. It was also expected that the application of vacuum would remove any gas evolved, and so eliminate surface defects and blow-holes. This proved to be the key to success, and satisfactory castings were made with compacts of various powder materials set into the walls of steel blocks and plates. As a further step, it was realized that with a fine powder the pressure difference across the powder layer at the mould cavity surface created by the vacuum was sufficient to hold the layer in place. Compacts were therefore not needed. The concept of a "vacuum core" then evolved, consisting basically of a box with a powder layer held on its surface by vacuum, Fig. 2. Such a core can be inserted into a space created in a mould such that the core's powder layer forms part of the cavity surface. Vacuum cores are prepared and used as follows:

1. The main cavity in the vacuum core is filled with a fine sand, and the vacuum is applied.

2. The sand is smoothed at the surface and with a suitable scraper about 1/8 is removed at the surface.

3. The 1/8 in. gap is refilled with abrasion-resistant powder, and the surface levelled off.

4. The core is inserted in the mould, and the powder layer continues to be held in place by the vacuum until metal is poured.

5. The vacuum line is removed shortly after pouring.

## DIGGER TOOTH PRODUCTION

Of the numerous severe wear attack applications in Syncrude's oil sands operations, digger teeth for bucket wheel reclaimers were selected as appropriate components for service evaluation of the CANMETCOAT procedure. A schematic drawing of a vacuum core to coat such a tooth is shown in Fig. 3. Steps in the production of these teeth are illustrated in Fig. 4. Figure 5 shows a section through a tooth. The CrC layer can be seen on the top, end, and part of the bottom surface. The first teeth were made at MTL's experimental foundry. Later the technology was transferred to a commercial foundry where over 100 teeth were cast. The assessment by the foundry was that the process in its present form does not easily lend itself to commercial production. The main problems are the cost of the metal cores, and the necessity to maintain vacuum on the cores once they are prepared. The latter causes the pouring schedule to be tied in with the preparation of the cores. To decouple the two operations, work is now proceeding on the production of cores with pre-bonded abrasion-resistant powder. Such cores can be installed in the mould ahead of time and the vacuum line connected just before pouring. Vacuum core cost

can be reduced by replacing the welded metal construction by a disposable core made entirely from bonded sand. A schematic drawing of a disposable sand core is shown in Fig. 6.

Experience with field testing of the coated teeth at the Syncrude plant is described in Part 2.

## REFERENCES


1. U.S. Patent No. 786,009, Mar 23 1905, F. Cowden and R.S. Logan, Process of Casting".

2. K. Herfurth and S. Pinkert "Surface Alloying of Steel Castings - a Combination of Casting and Coating"; Geissereitechnik, vol. 19, pp 367-374, 1973 (In German, translation available from CANMET library).

3. R.K. Buhr "Tests on Surface Alloying of Castings"; Test Report PM-65-9, Canada Dept. of Mines and Technical Surveys, Ottawa (Now Dept. of Energy, Mines and Resources).


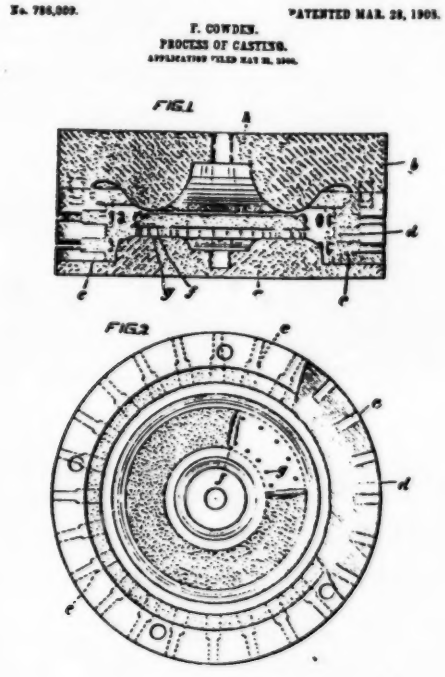


Fig. 1. Drawing from 1905 U.S. Patent 706009 showing the location of cardboard trays (position 'f') containing FeMn in a mould for a steel pump impeller casting.

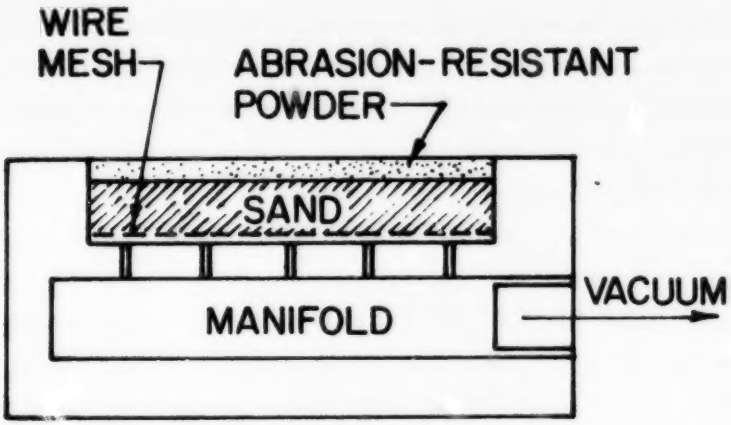


Fig. 2. Schematic of a vacuum core.

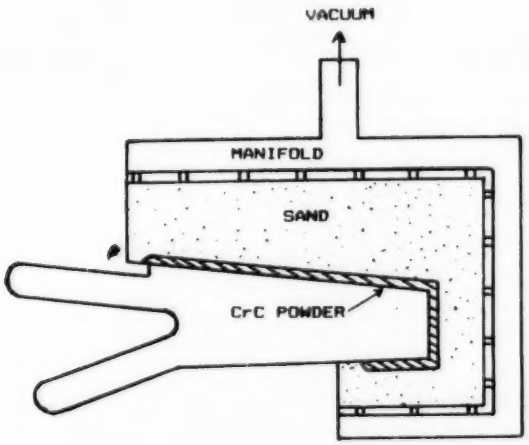


Fig 3. Schematic of a vacuum core for a digger tooth casting.

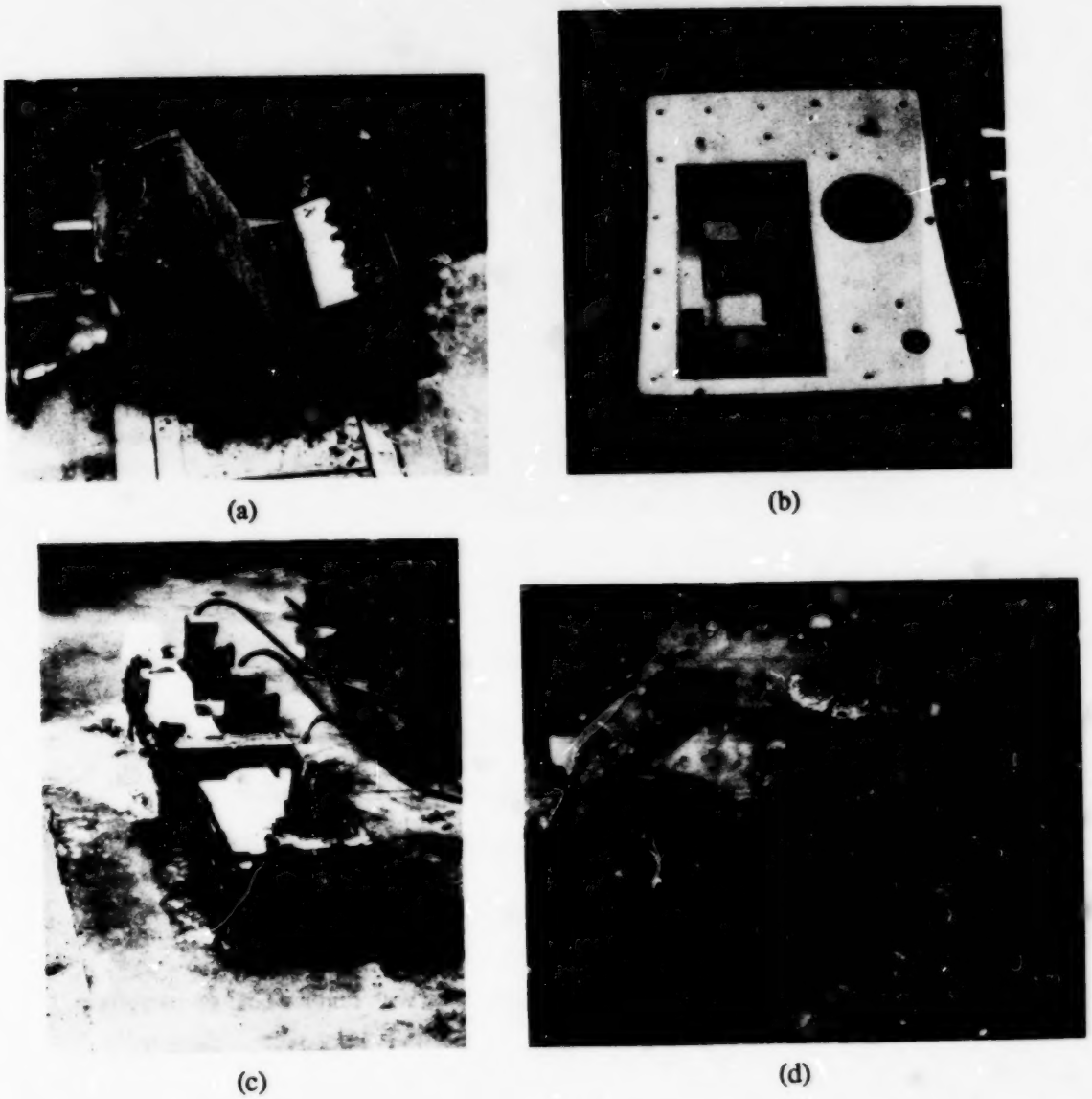


Fig 4. Production of a CANCOAT digger tooth casting. (a) Steel vacuum cores with CrC layer held in place by vacuum. (b) Digger tooth mould with opening into which core is lowered. (c) Moulds ready for pouring. (d) Coated casting on removal from the mould.

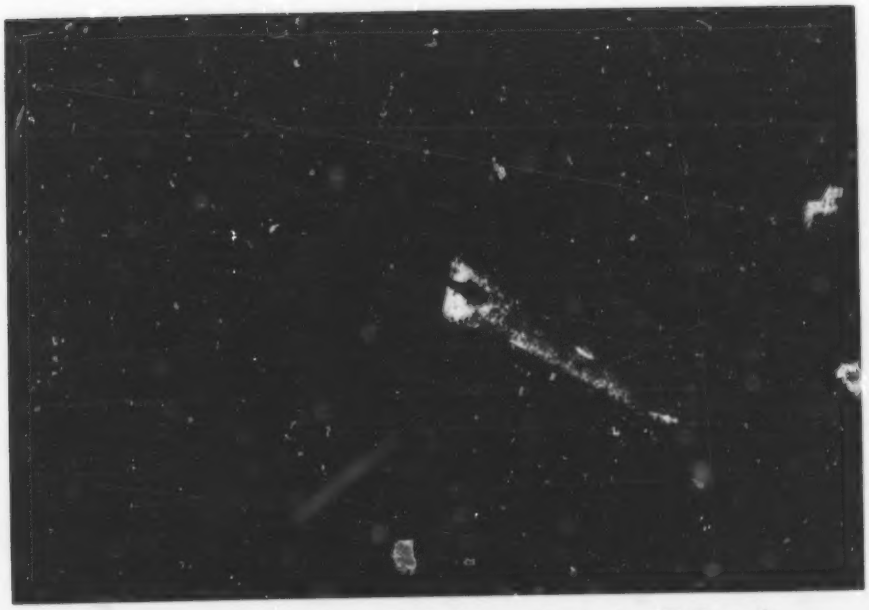

Fig 5. Sectioned CANMETCOAT tooth showing CrC coating.

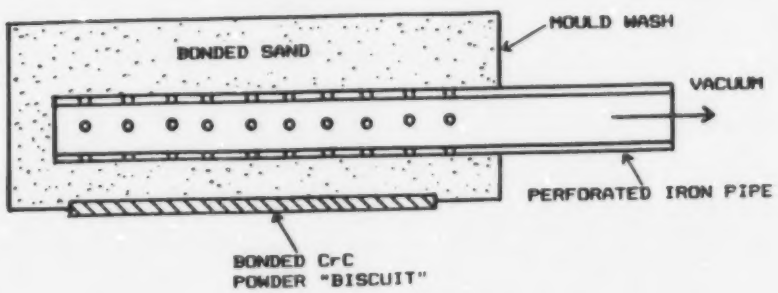


Fig 6. Schematic of disposable sand vacuum core with bonded CrC on its surface.

## NEGATIVE FILE NUMBERS

Fig. 1. 19739

Fig. 2. 19740

Fig. 3. 19738

Fig. 4. (a) 12438 (b) 12441
(c) 12442 (d) 12440

Fig. 5. 19724

Fig. 6. 19928